Knowledge Diffusion Among Engineers and Scientists

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Paper presented at the Defense Technical Information Center's
1997 Annual Users Meeting & Training Conference
Wednesday, November 5, 1997

DoubleTree Hotel National Airport
Arlington, Virginia

Organization of the Presentation

- Project objectives for the NASA/DoD Aerospace Knowledge Diffusion Research Project
- A Discussion of the Role and Importance of Knowledge in a Global Economy
- An Examination of Knowledge Management within Industry and Government
- Recommendations for a Knowledge Management Structure for Aeronautical R&T

The Aerospace Knowledge Diffusion Research Project Team

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OBJECTIVES

- Provide descriptive and analytical data about the diffusion of knowledge in aerospace at the individual, organizational, national, and international levels

- Examine the channels and the social system through which aerospace knowledge diffuses and the community in which aerospace knowledge is produced, transferred, and used

- Investigate the information-seeking habits, practices, and behaviors of aerospace engineers and scientists

- Determine the role of the technical report, the library, and information intermediaries in the diffusion of aerospace knowledge

KNOWLEDGE

Knowledge differs from other so-called commodities or resources:

- It is not depleted with use, it is sharable, and traditionally, it has had no intrinsic value
- It is difficult to distinguish between knowledge and the medium in which it is contained
- Except for knowledge-based products and services designed to be sold, most knowledge lacks markets in which value can be determined by supply and demand
- Numerous individuals located at various points across the globe can possess the same knowledge, unlike other commodities or resources

KNOWLEDGE

- The past 20 years have witnessed the propensity of knowledge to cross national boundaries, a phenomenon that observers have labeled the *globalization of knowledge*

- The boundary–spanning propensity of knowledge is due mainly to improvements in communications (e.g., the Internet), transportation (e.g., international air travel), and the fact that developed and developing countries are spending more on creating and acquiring knowledge

- According to Peter Drucker:

  "Knowledge knows no boundaries. There is no domestic knowledge and no international knowledge. There is only knowledge. And with knowledge becoming the key resource, there is only a world economy."

TYPES OF KNOWLEDGE

When a firm or organization innovates, that is, creates or improves a process, product, system, or service, it generally does so by using both *tacit* and *explicit* knowledge.

- *Tacit* knowledge is personal, context-specific, and therefore, hard to formalize and communicate

- *Tacit* knowledge tends to be experiential and subjective. It is derived from practice, created in a specific context, and has an "analog" quality

- *Tacit* knowledge is extremely difficult to transfer without personal contact, demonstration, and involvement. In the absence of close human contact, the diffusion of tacit knowledge is sometimes impossible

TYPES OF KNOWLEDGE

- *Tacit* knowledge cannot always be codified because it often contains an important dimension of "know-how." Individuals may know more than they are able to articulate

- *Tacit*, unlike other forms of knowledge, is often costly, difficult, and sometimes impossible to acquire, transfer, and use owing to the attributes of tacit knowledge itself

- *Explicit* knowledge is codified and refers to knowledge that is transmittable in formal, systematic language and includes grammatical statements, mathematical expressions, specifications, and manuals

- *Explicit* knowledge tends to be rational and objective; it is derived from what is known and accepted and it is oriented toward context-free theory

INTERNATIONAL ECONOMIC LANDSCAPE

- Economic growth and job creation are important to all nations
- Today's global economy is characterized by alliances, partnerships, and joint ventures
- Knowledge is *the* critical element in innovation, technological progress, and economic growth
- Developed and developing nations are devoting more resources to knowledge creation, thus increasing the global pool of knowledge
- Once largely ignored, discounted or treated as a by-product of R&D, knowledge is becoming an important component of management theories

INTERNATIONAL ECONOMIC LANDSCAPE

The realities of the new global economy include:

- An increasing trend toward global technological and economic integration
- The global spread of innovative and R&D activities
- Growing technological cooperation among firms and nations
- Rapid globalization of knowledge, markets, and technology
- The integration of company R&D and manufacturing to create highly competitive manufacturing infrastructures

KNOWLEDGE AND THE ECONOMY

- Knowledge *qua* capital represents a new and vital factor that must be added to the three factors of production—land, labor, and financial capital—traditionally studied by economists

- "The new source of wealth is not material, it is information, knowledge applied to work to create value."

- Knowledge and knowledge-based resources are both enabling and constraining factors in the development of innovation and competitive advantage

- A firm's competitive advantage flows from its unique knowledge

- Competitive advantage is often determined more by the knowledge that a firm is able to keep to itself and less by knowledge that is readily diffused, imitated, exhausted, or appropriated

KNOWLEDGE AND THE ECONOMY

- Organizations and governments are beginning to recognize the value of knowledge as a leveragable resource

- Knowledge has become an important determinant of competitiveness and, by extension, of a nation's economic well-being

- The ability of a firm to absorb, assimilate, and apply internal and external knowledge for commercial purposes is critical to its innovative capability

- No where is this more evident than in the aerospace industry, whose complex and ambitious technological developments and products incorporate a wide range of scientific and technical, explicit and tacit, process and product, and systems integration and managerial knowledge

KNOWLEDGE AND COMPETITIVENESS

- Many firms view knowledge, particularly specialized knowledge, as an essential ingredient for competitive success

- Theorists expect improvements in knowledge-based work to contribute significantly to industrial growth and gains in productivity

- Effectively managing the creation, transfer, and use of knowledge resources is now regarded as critical for a firm's survival and success

KNOWLEDGE AND COMPETITIVENESS

- Many firms already consider the strategic management of knowledge—the "intellectual assets" of an organization—a key corporate activity and have implemented knowledge management programs

- These programs emphasize the criticality of knowledge as a competitive asset and seek to maximize the ability of an organization to integrate and use various kinds of knowledge

- Many firms have appointed individuals at the executive level to manage and direct the utilization of the organization's intellectual assets.

- These individuals are known by a variety of titles—that describe the scope and direction of an organization's knowledge management initiatives

What is Knowledge Management? OUR answer.

- A "help system" for the organization
- The more formal answer: A set of business practices characterized by:
  - Knowledge as an explicit concern of business in strategy, policy, and practice at all levels of the organization
  - Direct link between intellectual assets and positive business results

Knowledge at Work

Why you need to manage knowledge in your organization

- Most of our work is information based
- Competition on the basis of knowledge
- Complex products and services
- The need for life-long learning
- World Wide Web and corporate intranets
- The pace of change in business
- The **primary** opportunity

Knowledge at Work

Key concepts of KM

- Centralization and access to information
- Acceptance of the value of knowledge and the need to make it explicit
- Development of explicit management practices for the knowledge-based organization
- Transition from publishing and training to providing answers and solutions
- Qualitative, semantic organization of knowledge
- Shift from information access to filtering, abstraction, and value

Technologies and Disciplines Contributing to KM (1)

- Expert Systems, Knowledgebase Management Systems, and AI
- Back-of-the-Book Indexing
- Case-Based Reasoning Systems
- Cognitive Science
- Competitive Analysis
- Groupware, CSCW
- Decision Support Systems
- Document Management
- Full-Text Search and Retrieval
- Geographic Information Systems
- Help-Desk Systems
- Hypertext

Knowledge at Work

Technologies and Disciplines Contributing to KM (2)

- [Applied] Informatics
- Information Modeling
- Intranets and Corporate Electronic Publishing
- Library and Information Science
- Computer-based Ontologies
- Performance-Support Systems
- Qualitative Analysis
- Relational and Object Databases
- Semantic Networks
- Simulation
- Human Factors and Ergonomics
- Technical Writing and Training

Categorizing approaches to knowledge management

- Mechanistic approaches to knowledge management
- Cultural/behavioristic approaches to knowledge management
- Systematic approaches to knowledge management

Knowledge at Work

Origins in management theory and business practices

- A brief history of KM theory
- Benchmarking, Best Practices/Lessons Learned
- Change Management
- Risk Management
- Competitive Intelligence

Knowledge at Work

Who's doing it now?

- Some statistics:
  - > 40% of the Fortune 1000 now practice KM
  - Dataquest estimates 1997 corporate spending to leverage knowledge = $ 4.5B
  - 100 European firms plan to boost spending on KM activities by 70% in next 3 years
  - > 60% of Fortune 1000 firms in CAP Ventures study have formal knowledge management programs
- The Big Five and smaller consulting firms offer KM and KM-related services
- Industries include utilities, chemicals, pharmaceuticals, insurance and financial services, manufacturing, computers, telecommunications, and the public sector
- Many of you have been doing it under different names

Knowledge at Work

Who's doing it now?

- Initiatives within the federal government
  - National Security Agency
  - GAO
  - DoD (Army and Marine Corps)
  - Others

What is KM like right now?

- Emphasis on organizational access
- Close associations with intranets, groupware, and document management
- Help desks and customer support
- Competitive intelligence

Knowledge at Work

The current buzz about KM

- A spate of new books, articles, buzz words, and metaphors
- KM as a management prerogative
- Technology as a straw man
- Two major ideological camps
  - Knowledge creation and innovation
  - Managing and sharing existing knowledge

The innovation bandwagon

- Is knowledge management about innovation?
- What's the relationship between knowledge and innovation?
- Contrast: managing and sharing existing knowledge

Knowledge at Work

Above all else: critical thinking

- Find the hidden assumptions and agendas
- Metaphors are not business rules
- "And we know how charlatans tend to cower in the crevices between subjects."
  - From "Information versus Knowledge and Understanding," Murray Gell-Mann, Santa Fe Institute.

Knowing what you know … and don't know

- Auditing knowledge resources
- Internal and external perceptions of what business you are in
- Locating the knowledge deficits
- Finding out who has that information or where it is
- What form it is in

Building a KM program requires

- Defining/identifying the issues and goals associated with managing knowledge in your organization
- Knowing what you know -- mapping organizational and individual knowledge and using it to address business objectives
  - Articulate personal and corporate know-how
  - Identify knowledge critical to the firm and classify it
  - Identify and leverage core competences
  - Ensure consistent presentation and use of recorded knowledge
  - Direct employees to the knowledge they need when they need it
  - Re-use and leverage existing knowledge
  - Import external knowledge as needed
  - Support continuous learning and change

Knowledge at Work

Building a KM program requires

- Addressing organizational, cultural, and technological factors to ensure that everyone participates in managing knowledge
- Building a pilot project to test assumptions and support the business case

Knowledge at Work

Implementing a knowledge management program

- A strategic plan should include the following:
  - Create explicit models for knowledge resources
  - Identify employees skills' and know-how
  - Map the location of knowledge resources
  - Identify gaps in the organizational knowledgebase and develop/import knowledge as needed
  - Find/develop tools to support collaboration (CSCW)
  - Formally promote cooperation and teamwork among employees
  - Encourage creative approaches to problem-solving
  - Motivate/reward employees for sharing knowledge
  - Measure/evaluate the success of KM practices

Knowledge at Work

Selecting metrics

- How do you measure the value of knowledge?
  IC = MV-BV (Intellectual capital = market value less book value)
- What unit of analysis works? Knowledge-based outcomes and criteria for value
- Measuring intangible as well as tangible results
  - Employee participation in knowledge sharing
  - Improved efficiency of specific processes
  - Improved productivity of knowledge work
  - Growth of organizational knowledge base
  - Greater customer satisfaction
  - Decreased production costs
  - Fewer defects, less waste
  - Increased sales
  - Shorter cycle time for product development

Knowledge at Work

DEVELOPING A KNOWLEDGE MANAGEMENT STRUCTURE FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

Developing a basic knowledge management structure to optimize diffusion aeronautical R&T would require taking the following actions:

1. Model (i.e., categorize and represent) knowledge in a problem-solution context that not only promotes the diffusion of explicit knowledge but also supports the elicitation of tacit knowledge.

   The knowledge model should be based on user-specified needs and should represent knowledge in standard, non-proprietary formats to ensure its reusability and longevity

DEVELOPING A KNOWLEDGE MANAGEMENT STRUCTURE FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

2. Array consistently (according to agreed upon standards and formats) the knowledge resulting from such activities as wind tunnel tests and flight test programs so that users can easily identify, acquire, evaluate, interpret, and integrate it into their internal knowledge bases

3. Monitor (i.e., acquire), screen, evaluate, interpret, and integrate published (explicit) aerospace knowledge originating outside the organization into the knowledge base for diffusion through-out the aeronautics enterprise

DEVELOPING A KNOWLEDGE MANAGEMENT STRUCTURE FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

4. Optimize the two-way flow of explicit and tacit knowledge by sponsoring and supporting informal technical discussions; conferences, symposia, and workshops; contracts with industry; non-contract cooperative programs; technology demonstration programs; and government-academia-industry personnel exchange programs

5. Develop mechanisms that help knowledge seekers identify and locate sources of tacit knowledge and expertise (i.e., subject-matter experts) through the creation of such information technology-enabled products as online yellow pages

DEVELOPING A KNOWLEDGE MANAGEMENT STRUCTURE FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

6. Develop mechanisms that facilitate awareness among the members of the aeronautics enterprise of explicit knowledge and that include announcements and updates of recently initiated and on-going in-house performed and -sponsored research (e.g., grants and research contracts)

7. Establish guidelines and mechanisms for knowledge diffusion to ensure that competitors do not benefit unduly from receiving the results of in-house performed aeronautical R&T

8. Evaluate the knowledge exchanged as a result of bilateral agreements with foreign governments and institutions to ensure *quid pro quo* on the basis of quantity and quality

DEVELOPING A KNOWLEDGE MANAGEMENT STRUCTURE FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

9. Develop mechanisms for identifying and tracking the activities and expertise of external aeronautical research programs, facilities, and personnel (i.e., competitive intelligence) and diffuse it to interested parties within the aeronautics enterprise

10. Develop an evaluation component with metrics that relies on user input and feedback for determining the knowledge needs of the aerospace enterprise and assessing the efficacy of the aerospace knowledge management program

DEVELOPING A KNOWLEDGE MANAGEMENT STRUCTURE FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

11. Recognize knowledge management as a legitimate element of the research process, and identify and assign responsibilities for managing knowledge at all levels of the organization

12. Budget and allocate funding for knowledge management activities through the aeronautical R&T program to ensure that knowledge diffusion becomes an integral part of the R&T program

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